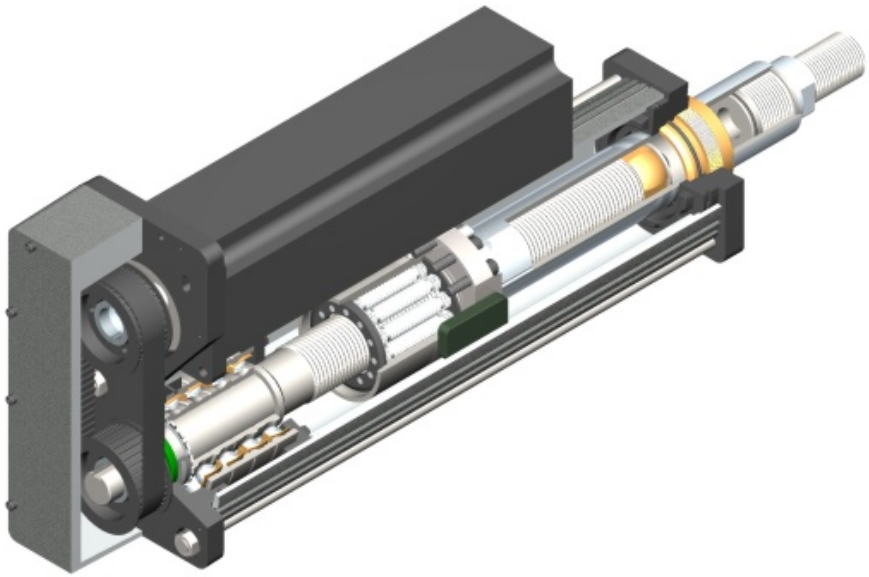
Force Tube Satellite Roller Screw Actuators
Installation & Service Manual



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1.0 Introduction

1.1 Warranty and Limitations of Liability

Exlar warrants its product(s) to the original purchaser and in the case of original equipment manufacturers, to their original customer to be free from defects in material and workmanship and to be made in accordance with Exlar's specifications for the product(s) as published at the time of purchase unless otherwise agreed to in writing by an authorized Exlar representative. In no event, however, shall Exlar be liable or have any responsibility under such warranty if the product(s) has been improperly stored, installed, used or maintained, or if Buyer has permitted any unauthorized modifications, adjustments and/or repairs to such product(s). Seller's obligation hereunder is limited solely to repairing or replacing (at its opinion), at the factory any product(s), or parts thereof, which prove to Seller's satisfaction to be defective as a result of defective materials, or workmanship and within the period of time, in accordance with the Seller's stated product warranty (see Terms and Conditions at www.exlar.com), provided, however, that written notice of claimed defects shall have been given to Exlar within thirty (30) days from the date of any such defect is first discovered. The product(s) claimed to be defective must be returned to Exlar, transportation prepaid by Buyer, with written specification of the claimed defect. Evidence acceptable to Exlar must be furnished that the claimed defects were not caused by misuse, abuse, or neglect by anyone other than Exlar.

Components such as seals, wipers, bearings, brakes, bushings, gears, splines, and roller screw parts are considered wear parts and must be inspected and serviced on a regular basis. Any damage caused by failure to properly lubricate Exlar products and/or to replace wear parts at appropriate times, is not covered by this warranty. Uses of components under load to the extent of their expected life according to typical ratings are not covered by this warranty. Any damage due to excessive loading is not covered by this warranty.

Costs for shipment of units returned to the factory for warranty repairs are the responsibility of the customer. Exlar will return ship all warranty repairs or replacements via UPS Ground at no cost to the customer.

For international customers, Exlar will return ship warranty repairs or replacements via UPS Expedited Service and cover the associated shipping costs. Any VAT or local country taxes are the responsibility of the customer.

The foregoing warranty is in lieu of all other warranties (except as Title), whether expressed or implied, including without limitation, any warranty of merchantability, or of fitness for any particular purpose, other than as expressly set forth and to the extent specified herein, and is in lieu of all other obligations or liabilities on the part of Exlar.

Seller's maximum liability with respect to these terms and conditions and any resulting sale, arising from any cause whatsoever, including without limitation, breach of contract or negligence, shall not exceed the price specified herein of the product(s) giving rise to the claim, and in no event shall Exlar be liable under this warranty otherwise for special, incidental or consequential damages, whether similar or dissimilar, of any nature arising or resulting from the purchase, installation, removal, repair, operation, use or breakdown of the product(s) or any other cause whatsoever, including negligence.

The foregoing warranty shall also apply to products or parts which have been repaired or replaced pursuant to such warranty, and within the period of time, in accordance with Seller's stated warranty.

No person including any agent or representative of Exlar, is authorized to make any representation or warranty on behalf of Exlar concerning any products manufactured by Exlar, except to refer purchasers to this warranty.

1.2 Safety Considerations

As with any electro-mechanical device, safety should be considered during installation and operation of your FT Series actuator. Throughout this manual you will see paragraphs marked with WARNING or CAUTION signs as shown below.

CAUTION

WARNING

Pay particular attention to these paragraphs. They are intended to provide you with helpful information to ensure a safe and trouble free installation and operation.

Care should be taken not to exceed the physical travel limits of FT Series actuators. Doing so will cause the actuator to end-crash internally. End crashes can physically damage the roller screw and the internal components of the actuator.

Care should be taken to avoid high speed impact with objects of high rigidity that immediately stop the travel of the actuator with no deceleration or energy absorption. An example would be a high speed impact of two solid steel parts. The resulting impact will create a very short effective deceleration time. Kinetic energy contained in the rotating inertia of the actuator and motor can possibly generate extremely high impact forces that exceed the mechanical capacities of the actuator and cause physical damage to the actuator. For applications requiring this type of impact, contact Exlar application engineering to insure that the actuator is properly sized or provisions made to absorb the induced energy.

1.3 Force Tube (FT) Series Roller Screw Based Linear Actuators Overview

Exlar Force Tube actuators are offered in three standard frame sizes of 3.5" (FT35), 6" (FT60), and 8"(FT80). Continuous duty thrust load ratings of 2000 lbf up to 20,000 lbf with peak load ratings of 2-3 times the continuous load ratings (see section 5.0 for complete product specification).

Exlar FT Series actuators utilize a satellite roller screw mechanism that converts rotary motion to linear motion which is mounted within a sealed periscoping tube package. The roller screw follower (nut) is attached to the moveable "Force Tube"(output rod), which extends or retracts as the screw shaft is rotated. The general operating principle is illustrated below.

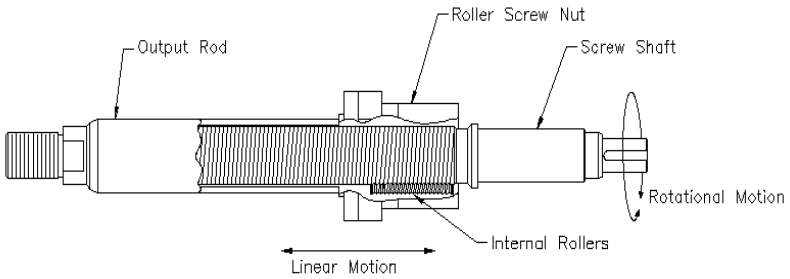

Figure 1: Actuator Operating Principle

The FT Series force tube design provides the contamination isolating advantages of hydraulic cylinders without the limitations of load, life, and speed which are inherent in ball screw and acme screw actuators. All rotary to linear conversion components are mounted within a sealed housing. This prevents abrasive particles and other forms of contamination from entering the actuator's critical mechanisms assuring trouble-free operation even in the most severe environments.

1.4 Basic Actuator Construction

All FT Series actuators are completely sealed from the outside environment by the use of O-Rings on both ends of the extruded aluminum case. The output rod runs through a wiper and seal, which are captured within a bronze gland insert that are typically employed in hydraulic type actuators.

The extruded aluminum case is epoxy coated (powder coated) on all external surfaces. In cases where a motor is mounted in a parallel configuration (see section 1.5) the pulley cover is also epoxy coated. All other aluminum parts (face plate, end plate, inline adapters etc.) are black anodized. All steel mounting parts (flange plates, side lug plates, trunnion plates, etc.) are finished with a black oxide finish. In all situations these finishes are intended to retard corrosion only.

In applications where corrosive chemicals are to come in contact with the actuator, it may be necessary to employ non-standard coatings or materials. Contact Exlar for more details.

Unless otherwise specified, the output rod on a standard FT Series actuator is manufactured from case hardened, chrome plated, plain carbon steel (AISI 1045 or 1050). The case hardened chrome plated rod provides a very tough and wear resistant surface for the rod seal to operate against (rod end and chamfer are not chrome plated).

If the surface of the output rod gets dinged or severally scratched, the wiper and or rod seal may be compromised, causing contamination of the internal components in the actuator.

The base metal used in the standard output rod does not resist corrosive environments. Custom materials or platings may need to be used if the output rod is to come in contact with a corrosively aggressive environment. Contact Exlar for more details.

The standard tie rods on all FT Series actuators are manufactured out of 17-4 PH stainless steel and are very corrosion resistant to most non-chlorine based chemicals.

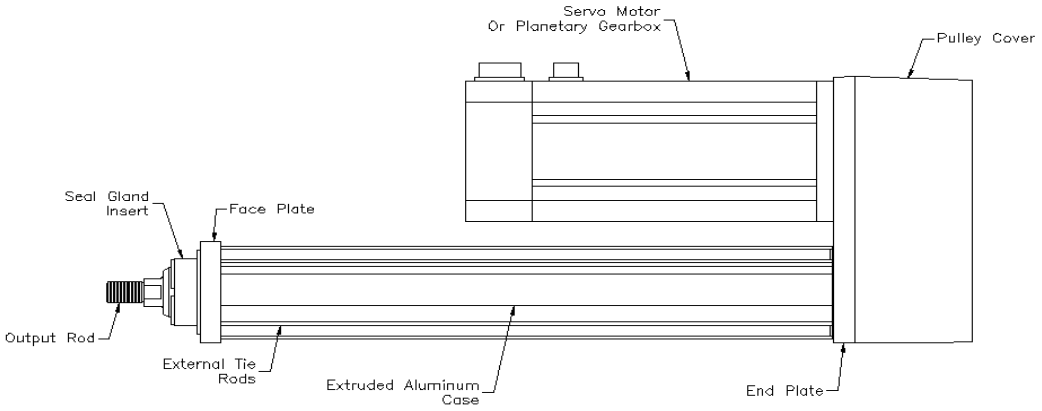

Figure 2: FT Actuator With Parallel Motor Mount

1.5 Actuator Drive Train Configurations

Exlar offers a base FT Series actuator model for the greatest flexibility in applying it in your application. The base actuator includes a high performance satellite roller screw assembly, pre-loaded angular contact bearing support, epoxy powder coated extruded aluminum housing, stainless steel tie-rods, precision internal anti-rotate bearings, sealed output rod, and a keyed input shaft for attachment to your drive system. A typical base FT Series actuator is shown below.

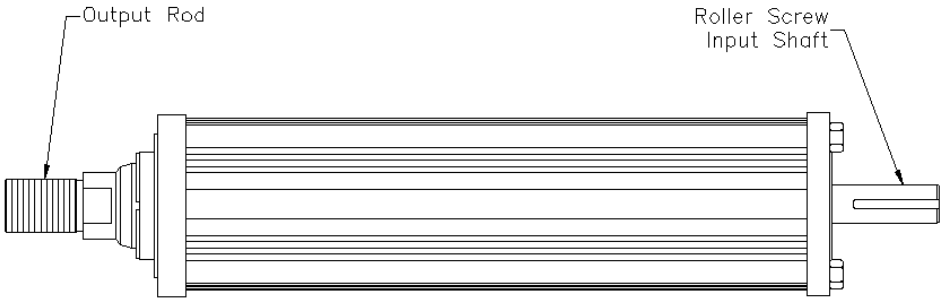

Figure 3: Base FT Actuator

Exlar also offers an FT Series actuator, which is the base actuator along with one of a variety motor mounting configurations, combined in one product package. The two that are offered as standard motor mounting configurations are parallel and inline. The parallel motor mounting configuration utilizes a high performance belt drive system, which while providing quiet operation, requires no re-tensioning for the life of the actuator as long as the motor is not removed or adjusted. The inline motor mounting configuration uses a zero backlash coupling to transmit power from the motor to the input shaft of the actuator.

Typically a drive ratio of 1:1 is used, but a 2:1 reduction ratio is also available as standard on the parallel motor mounting configuration. FT series actuators will also mate up with a wide variety of standard planetary gearboxes to attain higher input torque.

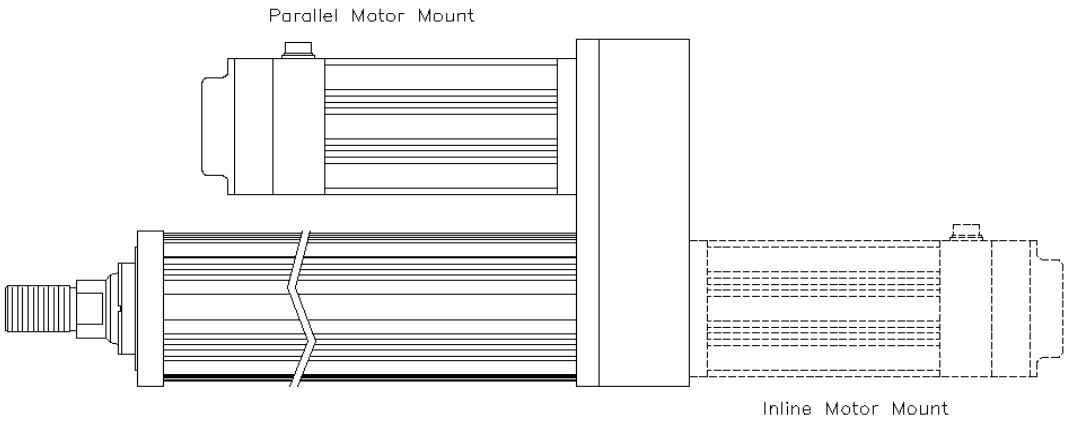

Figure 4: Motor Mounting Configurations

2.0 Installation

2.1 Mounting Configurations

The force tube actuators come with a variety of mounting configurations as well. The standard configurations available are Side Mount, Side Lugs, Extended Tie Rods, Rear Clevis, Front Flange, and Rear Flange. Side Mounted Trunnions, Front Mounted Trunnions, and combination Front and Rear Flange are also available.

2.2 Mounting Considerations

As with any linear actuator product, misalignment of the FT Series actuator with respect to whatever load the actuator is being used to move is of great concern. Any misalignment will decrease the life of the components within the actuator and also may create problems within the application associated with misalignment. Therefore every effort should be made to minimize misalignment as much as is possible.

Excessive side load on the output rod of the actuator will dramatically reduce the life of the actuator and should be avoided completely.

An FT Series actuator with the Side Mount option comes with threaded holes in the face plate and the end plate. Exlar recommends using hardened fasteners to mount an FT actuator to your machine frame. Exlar also recommends threading the mounting fastener into as much of the threaded hole in the actuator as possible, to prevent possibly stripping out the threads in the actuator's mounting holes. *Note: Side Mount and Side Lug actuators may have reduced maximum load rating.*

All FT80 Side Mount actuators also come with a ø5/8 dowel pin hole in both the face plate and the end plate. These dowel pin holes must be used in conjunction with hardened dowel pins when side mounting an FT80. Failure to do so can cause damage to the actuator.

An FT actuator with the Extended Tie Rod mounting option comes with hex nuts on the face plate that are tightened down enough to keep the actuator together during shipping. When mounting the actuator to your machine, these nuts should be removed and the tie rods should be placed through your machine frame and the nuts used on the back side of your machine's mounting flange. The tie rod nuts should then be tightened with a torque wrench to the following values:

FT35 = 16 ft-lbf
FT60 = 60 ft-lbf
FT80 = 127 ft-lbf

2.3 Lubrication

Exlar's FT Series actuators are shipped from the factory fully lubricated with a high temperature grease. Exlar recommends using Mobilith SHC 220, a high performance, extreme-pressure grease. The unique physical properties of the synthetic base oil provides outstanding protection against wear, rust, corrosion and high or low-temperature degradation. Mobilith SHC allows for very low starting and running torque values. Its operating range is -40 degrees C to 177 degrees C (-40 degrees F to 350 degrees F).

Alternative lubrication for custom configurations is to use high performance gear oil, contained within the actuator. Exlar recommends using Mobil SHC 627 high performance gear oil. These custom configurations can be provided with oil fill and drain plugs, and/or various devices for monitoring the oil level and condition. The application, orientation, travel speed, and other variables determine the oil level to be used. The proper oil level will be determined based on this information and supplied initially filled with this amount of oil.

Periodic inspection and renewal of the bearing and roller screw grease is recommended according to the periods shown in the table below. Follow the procedure in section 3.6 for renewing the lubrication.

RMS Rotational Speed (rpm)	Recommended Lubrication Renewal Period (hours)
250	10,000
500	10,000
1000	8000
1500	7000
2000	5800
2500	5000

It is important to use RMS rotational speed to determine lubrication renewal period. To determine this value follow the equation below:

$$V_{rms} = [(V_1^2 t_1 + V_2^2 t_2 + V_3^2 t_3 + \ldots)/(t_1 + t_2 + t_3 + \ldots)]^{1/2}$$

Where:

V_{rms} = RMS Rotational speed (rpm)
$V_{1,2,3...}$ = Rotational speed of roller screw shaft for corresponding $t_{1,2,3...}$ time (rpm)
$t_{1,2,3...}$ = Time at corresponding $V_{1,2,3...}$ rotational speed (minutes)

Upon initial startup of your FT Series actuator, cold grease may cause increased motor torque to operate actuator. Once grease has warmed up required motor torque should decrease. Elevated operating temperatures may result in shorter lubrication renewal periods.

For lubrication of seals see section 3.1.
For inspection and lubrication procedure see section 3.6.

2.4 Anti-Rotate Mechanism

Exlar's FT Series actuators have an internal anti-rotate mechanism, which is supported by bearings that ride on channels, which are part of the extruded case. This precise mechanism will limit angular backlash to 0.35 degrees rotation and is designed to withstand the high force and speed created by these actuators. However, there is a limit to the amount of torque they can withstand, and every effort should be made to resist installation torque applied when tightening a nut or coupling on the output rod. There are wrench flats provided on every standard output rod to aid in resisting installation torque.

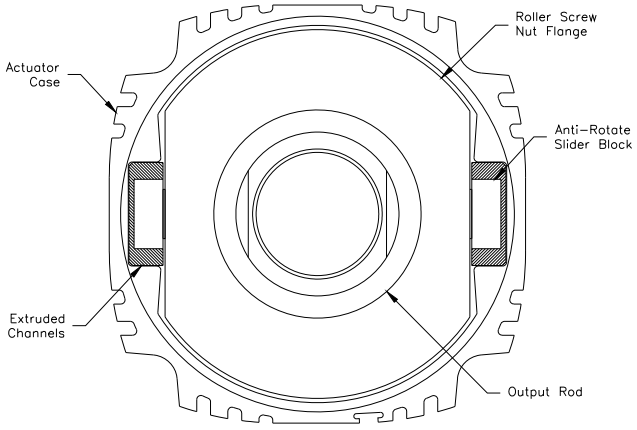

Figure 5: Anti-Rotate Mechanism

During installation do not apply more than the following values for torque to the output rod without opposing that torque. Doing so can damage the anti-rotate mechanism inside the actuator.

FT35----12 ft-lbf
FT60----50 ft-lbf
FT80----100 ft-lbf

3.0 Maintenance & Service

3.1 Seals

Both ends of the extruded housing on the FT actuator are sealed using BUNA-N O-Rings. The outer diameter of the output rod is sealed with a gland seal that utilizes a dual seal system with a wiper seal on the outside and a high pressure rod seal within the seal cartridge. Just below the gland seal thread another BUNA-N O-Ring is used to seal the gland seal itself to the front end plate. The input shaft is sealed using a spring loaded nitrile shaft seal that is contained within the back end plate of the actuator. These seals are lubricated on initial assembly with a Teflon grease however the front gland seal should have a small amount of mineral oil applied to it periodically depending on amount of actuator use or storage to keep the seal operating smoothly and to prolong life. All O-Rings are greased with a silicone grease designed to slightly swell the O-Ring to assure proper sealing (to standard MIL-G-4343).

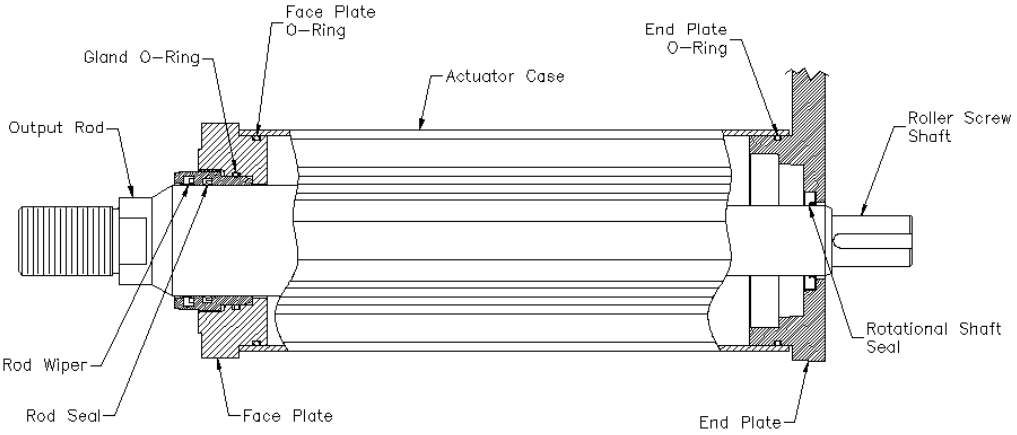

Figure 6: Actuator Sealing Details

3.2 Bearings

There are four angular contact bearings mounted in duplex arrangement, which are used to support the roller screw mechanism within the FT series actuator. The bearings are mounted in such a manner so that both the inner and outer races are pre-loaded. The inner races of the bearings are pre-loaded using a bearing jam nut and lock washer to ensure that the pre-loaded condition is not lost. The outer races are pre-loaded using either the external or internal tie rods.

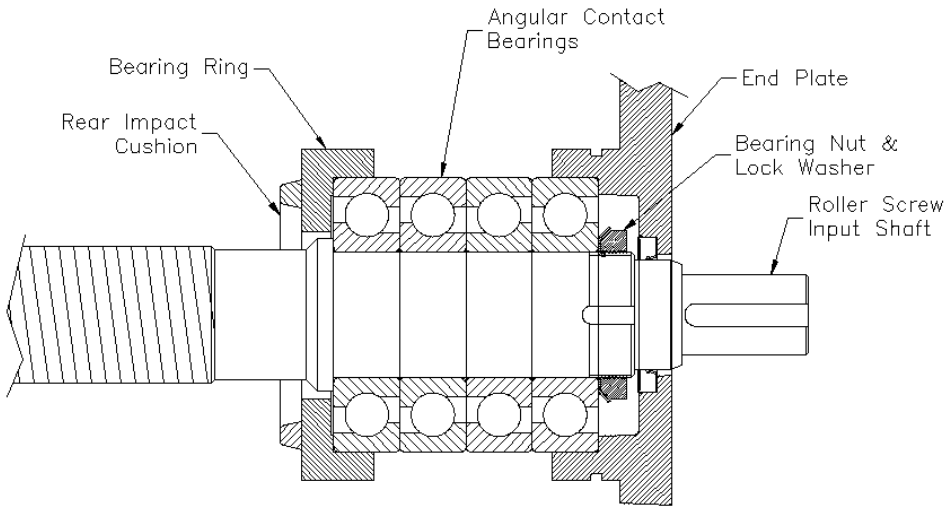

Figure 7: Roller Screw Support Bearing Detail

3.3 Drive Train

The FT Series actuators combined with a parallel motor mounting configuration use a polymer reinforced belt drive system. The drive train does not require any lubrication and any oil or dirt contamination within the belt drive system will decrease belt effectiveness and life. The belt and pulley system should be inspected periodically for excessive wear and proper tensioning.

Do not remove the belt cover while the actuator is operating. Always remove power from the attached motor before removing the belt cover to service any component of the drive train (i.e. belts, pulleys, bushings, inline couplings, gears, etc…). Failure to do so can result in damage to the actuator or cause serious injury to the operator.

Improper belt tension can cause premature belt wear and/or failure as well as belt noise and slippage. Consult Exlar for questions regarding proper belt tensioning. The following picture is only an example of a typical belt and pulley drive train in an FT Series actuator. For specific service concerns relating to your FT Series actuator's drive train consult Exlar.

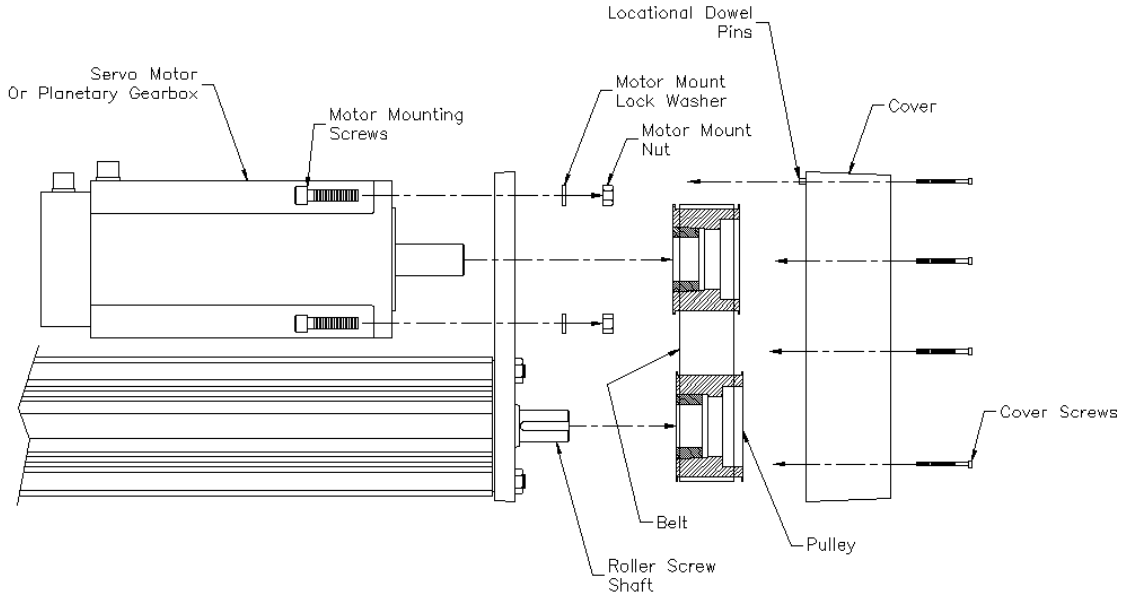

Figure 8: Parallel Motor Mount Drive Train Assembly

Proper Belt Tension

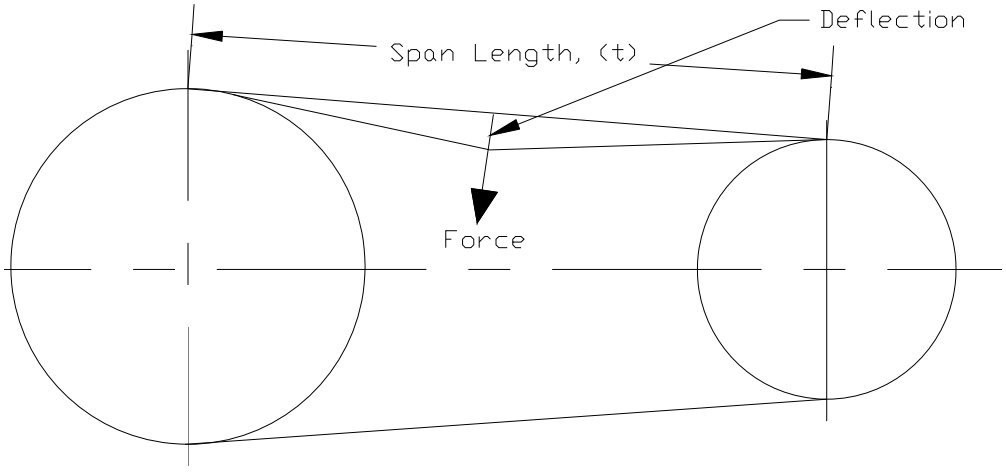

Figure 9: Belt Tension Diagram

These belt drives do not require as much tension as other belt drives that depend on friction to transmit the load. The installation procedure should begin by installing the belt with a snug fit,

neither too tight nor too loose. Now, measure the belt span, (t), as shown in the picture above. With one pulley free to rotate, use a spring scale to apply a perpendicular force to the center of the belt width at the mid-point of the belt span. For belts wider than 2", it is suggested that a strip of keystock, or something similar be placed across the belt under the point of force to prevent distortion. The appropriate amount of force for each belt is listed in the table below.

Measure the deflection of the belt at the mid-point. While applying the correct force, there should be 1/64" of deflection for each inch of belt span. For example, the total deflection for a 32" belt span is 32"*1/64" = ½".

Belt Pitch	Belt Width	Force
8 mm	12 mm	7 lbs.
8 mm	22 mm	15 lbs.
8 mm	35 mm	20 lbs.
8 mm	60 mm	35 lbs.

General Assembly Torques			
	FT35	FT60	FT80
Pulley Cover Screws (1/4-20)	110 lb*in	110 lb*in	N/A
(3/8-16)	N/A	N/A	240 lb*in

Motor Mounting Torques				
Screw Size	Torque		Screw Size	Torque
10-32	55 lb*in		1/2-13	85 lb*ft
1/4-20	110 lb*in		9/16-12	125 lb*ft
5/16-18	235 lb*in		5/8-11	150 lb*ft
3/8-16	35 lb*ft		11/16-12	150 lb*ft
7/16-14	55 lb*ft		3/4-10	150 lf*ft

3.4 Roller Screw

The satellite roller screw used within the FT Series actuators is a precision-machined mechanism, which is fully greased upon assembly. Lubrication of the roller screw should be maintained in accordance with section 2.3. The biggest enemies to this mechanism are shock loading and radial loads (side loads). Loading the roller screw in such a manor will cause premature failure.

Do not run the roller screw into the end of its stroke (in either extension or retraction), as this will severely damage the actuator and/or application.

For roller screw life calculations and specifications see section 5.0.

3.5 End Of Stroke Cushions

Every standard FT Series actuator is equipped with nitrile rubber impact bumpers, which are designed to protect the actuator from accidental over extension or retraction.

This is a fail safe only and should not be used as a limit to stroke.

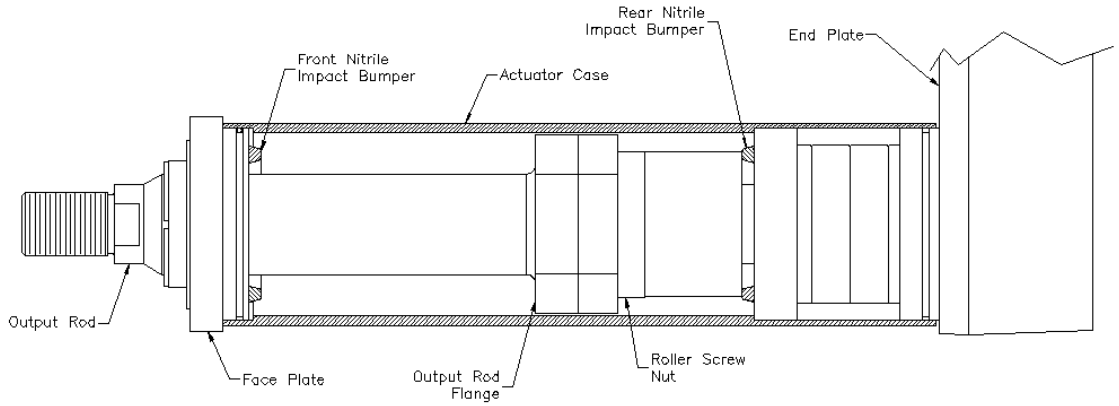

Figure 10: Actuator End of Stroke Cushions

Care should be taken not to exceed the physical travel limits of FT Series actuators. Doing so will cause the actuator to end-crash internally. End crashes can physically damage the roller screw and the internal components of the actuator.

3.6 Inspection and Lubrication Procedure

The following disassembly and reassembling procedures are general guidelines. Individual designs may differ from these procedures and any questions should be verified with Exlar before reassembling and reinstalling the actuator into your machine or application. For both procedures refer to the drawings included in the disassembly procedure for reference only.

If your actuator has a preloaded roller screw, do not remove it from the cylinder. Preloaded screws require special tooling and procedures for proper disassembly and reassembly. Contact Exlar Corporation to arrange for maintenance of a preloaded screw actuator.

Disassembly:

1. Remove the actuator assembly from the application or machine by removing power from the motor, disconnecting main rod coupling and actuator mounting bolts or fasteners. If the servo

motor/ gearbox is mounted inline proceed to step 5. If the servo motor is parallel mounted skip steps 5 and 6.

2. Remove pulley cover by removing cover screws and pulling cover away from end plate. There are dowel pins that are pressed into the pulley cover that will hold the cover to the end plate and may make it difficult to pull the cover away from the end plate.
3. Loosen motor mounting screws and slide motor down to relieve tension on belt.

4. Remove screws from roller screw shaft pulley and use these same screws to push the pulley bushing off of the pulley using the back out threads provided in the pulley or bushing. Once the pulley becomes loose remove it and the belt. Then remove the motor pulley and bushing and remove the motor from the end plate taking note to record how far from the end plate that the bushing is mounted. This will aid in reassembling the drive train.

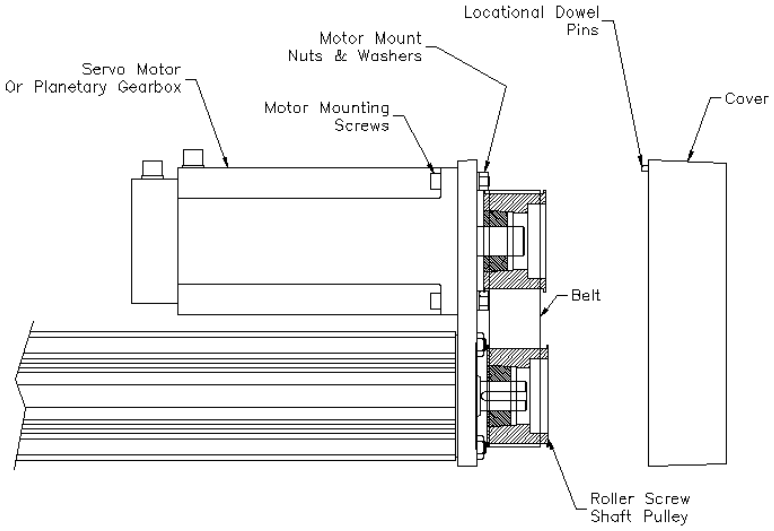

Figure11: Parallel Motor Mount Disassembly

5. Loosen the inline coupling screws by getting at them through the plug holes or adapter cover in the side of the inline adapter. Remove the servo motor (and if necessary, the motor mounting plate) after removing the motor mounting screws.

6. Remove the inline adapter after removing the adapter mounting screws.

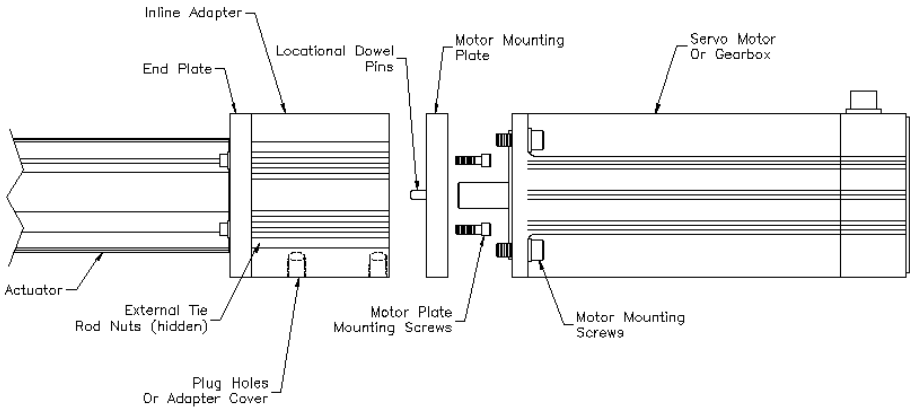

Figure 12: Inline Motor Mount Disassembly

7. Remove the external tie rod nuts and lock washers. If there are any side mounted trunnion plates, remove these at this time as well.

8. Pull the face plate (and or flange plate) away from the case along with the external tie rods. Then pull the case in the same direction and remove it from the actuator. The roller screw and bearings will now be exposed.

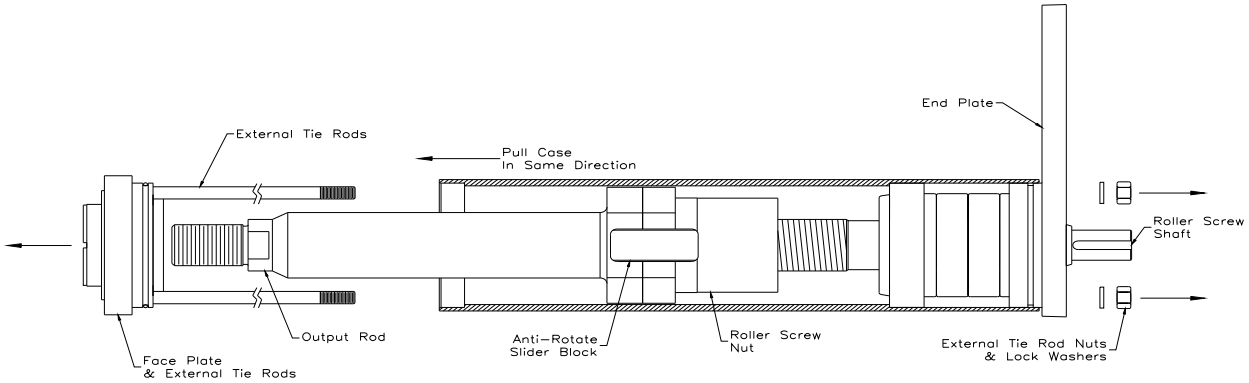

Figure 13: Actuator Disassembly

9. To expose the bottom set of angular contact bearings for re-lubrication you will need to remove the end plate. This is pressed onto the outer race of the bearings (on FT80's you will need to remove the internal tie rod nuts first). Pull it away from the bearing pack to expose the bottom bearing. This may take some doing and tapping it lightly with a rubber mallet may be necessary. You will now be able to re-grease the roller screw and bearings.

Regreasing:

1. It is a good idea to remove old grease before applying new grease to roller screw bearings and anti-rotate slider tracks. To re-grease the roller screw, fully extend the output rod by rotating the roller screw nut and output rod exposing as much of the roller screw as possible. FOREIGN OBJECTS WILL DAMAGE THE ROLLER SCREW AND SHOULD BE PREVENTED FROM STICKING TO THE GREASE. Apply new grease with a brush or grease gun. Apply enough grease to cover 1/3 of the roller screw diameter on the entire exposed length. Excessive grease is unnecessary and will only require higher motor torque to operate the actuator. Screw the roller screw nut back down until almost fully retracted.

2. To re-grease the bearings, obtain a grease gun with a needle that will fit in between the balls of the bearings. Insert the needle into the bearings to work grease into the inside two bearings, then grease the outside two. Again, excessive grease is unnecessary and will only require higher motor torque to operate the actuator.

3. To re-grease the anti-rotate slider block tracks in the case, apply a thin bead (approximately 1/8" diameter) to each of the four outside corners and the middle of the outer wall of the rectangular tracks in the case using a grease gun. Extend the beads as far into the case as possible, and work from both ends of the case if necessary. If the actuator is too long to obtain continuous beads along the entire track length, the slider will distribute some of the grease as it travels through the first few cycles after reassembly.

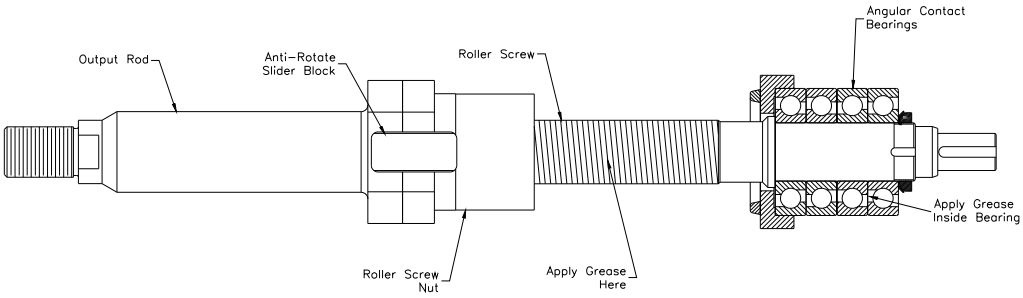

Figure 14: Actuator Greasing Detail

Reassemble the Actuator:

1. Apply a small amount of grease to the rotational seal. Press or tap the end plate back onto the bearing pack with a rubber mallet, taking care not to damage the rotational seal. The end plate must go onto the bearing O.D. straight or it will not go on easily. If it gets stuck, take it off and restart it on the bearing O.D. again. FT80's have tie rods that pre-load the outer races of the bearings. These tie rod nuts (3/8-16 hex nuts) should be tightened to 42 Ft-Lbf with a torque wrench. Alternate tightening in a cross circular pattern to allow for a straight assembly.

2. Slip the case down over the output rod (deeper bore goes towards the bearing pack), while taking care to line up the limit switch groove in the case with the target magnet that is located in the output rod flange (FT60 & FT80) or roller screw nut flange (FT35). Also make sure that the anti-rotate bearings line up with the extruded channels in the case. Orient the switch in the desired position and push the case down over the bearing ring and end plate O-Ring. On FT35's and FT60's the case WILL NOT seat on the end plate when fully assembled and on FT80's the case WILL seat on the end plate.

3. Apply a small amount of grease to the output rod seal and some to the output rod and slide the face plate with external tie rods down over the case and output rod and insert the tie rods through their respective holes in the end plate. The rod seal in the bronze gland insert will take some pressure to get it past the chamfer on the output rod, however take care not to damage the seal or wiper.

4. Put the lock washers and nuts on the external tie rods and tighten the nuts with a torque wrench to the following values below:

FT35 = 16 ft-lbf
FT60 = 60 ft-lbf
FT80 = 127 ft-lbf

5. The motor and drive train can now be reassembled. On FT's that have a belt and pulley drive train (parallel motor mount) check the belt for wear. If the belt has excessive wear it may be necessary to replace it. When reassembling the pulleys and belt it is important to line up the pulleys to each other while obtaining the maximum amount of bushing engagement on the motor shaft. If the pulleys are not lined up premature wear could cause the belt to fail. Consult Exlar for the proper belt tension and pulley/bushing screw torque. On inline motor mounted drive trains consult Exlar for proper screw torque for inline coupling.

4.0 Optional Equipment

4.1 Pre-Loaded Follower

Exlar is able to provide a zero backlash FT series actuator by employing a pre-loaded screw follower. These pre-loaded followers can be made in standard leads and stroke lengths and operate under the same principals as the non-pre-loaded followers. However a pre-loaded screw follower will have a decreased life due to the initial force applied to the rollers inherent in the pre-loaded condition. *See section 5.0 for details regarding these life calculations.*

The anti-rotate mechanism inside every FT actuator has angular backlash associated with it and should be considered when applying an FT actuator in a backlash critical application. Different coupling methods may also effect overall system backlash.

4.2 Mounting Options

As mentioned in section 2.1, standard mounting configurations on most models are Side Mount, Extended Tie Rod Mount, Front Flange Mount, Rear Clevis Mount, and Rear Flange Mount. Optional Side Mounted Trunnions, Front Mounted Trunnions, and combination Front and Rear Flange Mount are also available. Non-standard mounting styles may not be available on all units. Consult Exlar for details.

4.3 Standard Motor Mounting Configurations

The FT Series actuators are offered in two standard motor mounting configurations, parallel and inline. Each standard motor mounting is designed to accommodate any one of the many standard servo motors or planetary gearboxes offered from a wide variety of manufactures. Exlar suggests that you send the motor to our facility for mounting on the actuator to avoid problems associated with mounting the belt drive or inline coupling system. *See section 1.5 for more details.*

4.4 Limit Switches

The FT Series actuator is offered with externally mounted stroke limiting switches which can be moved externally to limit how far the actuator output rod will travel before it trips the limit switch. The switch is a Hall effect type switch that is triggered by a target magnet that is located on the back end of the output rod inside of the actuator housing. The standard switches are normally closed with PNP output. The switch power is 10-30 VDC with a no-load operating current of 2 mA and a load current of less than or equal to 200 mA. The time delay for the switch is 5 mS and the maximum approach speed is 10 m/S. Follow the diagram below for proper wiring and operation of the limit switches.

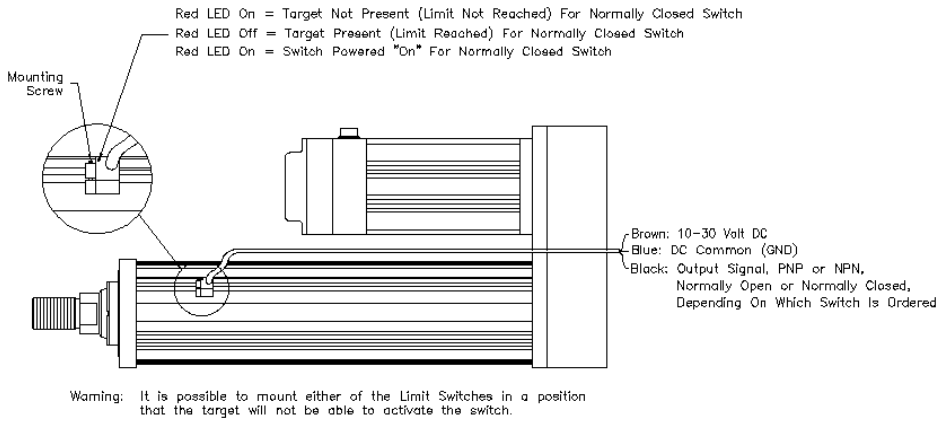
Red LED On = Target Not Present (Limit Not Reached) For Normally Closed Switch
Red LED Off = Target Present (Limit Reached) For Normally Closed Switch
Red LED On = Switch Powered "On" For Normally Closed Switch
Mounting Screw
Brown: 10-30 Volt DC
Blue: DC Common (GND)
Black: Output Signal, PNP or NPN, Normally Open or Normally Closed, Depending On Which Switch Is Ordered
Warning: It is possible to mount either of the Limit Switches in a position that the target will not be able to activate the switch.

Figure 15: Adjustable Limit Switch Wiring

4.5 Rod Ends

FT series actuators are available as standard with male rod ends with either U.S. Unified or Metric threads. Female threads are also available but are a special and Exlar should be consulted for availability and cost. Each standard rod end is also equipped with wrench flats to aid in attachment to the load.

	A	B	øC	D	øE	F	Male U.S.	Male Metric	Female U.S.	Female Metric
FT35	0.87	1.125	1.000	0.500	1.750	0.750	3/4-16 UNF-2A	M16x1.5	3/4-16 UNF-2A	M16x1.5
FT60	2.00	2.750	2.360	1.025	3.000	2.000	1 7/8-12 UN-2A	M42x4.5	1 7/8-12 UN-2A	M42x4.5
FT80	2.75	4.019	3.143	1.250	4.000	2.250	2 1/2-12 UN-2A	M56x5.5	2 1/2-12 UN-2A	M56x5.5

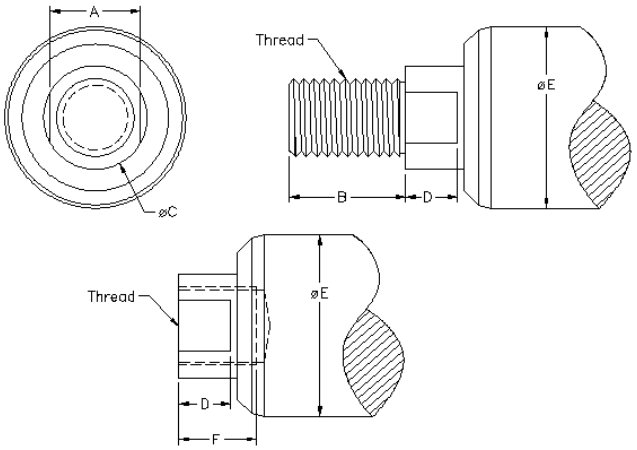

Figure 16: FT Rod End Thread Details

4.6 Motors

FT Series actuators are designed to accept virtually any type of standard electric servo motor or planetary gear reducer which are available through a wide variety of manufactures. Due to motor size, torque or speed, not all motors or reducers can be mounted to each standard Force Tube. Custom motor mounting may be required. *See section 5.0 for torque specifications required to drive application load levels*.

4.7 Electronics

Electronics and drive amplifiers to match the appropriate motors are available through the same manufactures that supply the motors. All maintenance and service guidelines contained within the motor manufacture manuals should be followed to avoid service problems associated with the amplifier and motor.

5.0 Specifications

5.1 Life Calculations

The expected life of the roller screw in an FT actuator is expressed as the linear travel distance that 90% of the screws are expected to meet or exceed before experiencing metal fatigue. This is not a guarantee. For accurate lifetime calculations of a roller screw in a linear application, cubic mean load should be used. The mathematical formulas that define these values follow the chart below.

Dynamic Load Rating		
FT Model	**Screw Lead In (mm)**	**Dynamic Load (Std. Follower) Kip (kN)**
FT35-XX05	0.2 (5)	10.7 (47.5)
FT35-XX10	0.39 (10)	8.7 (38.5)
FT35-XX20	0.79 (20)	7.1 (31.5)
FT60-XX06	0.23 (6)	51.9 (231)
FT60-XX12	0.47 (12)	44.6 (199)
FT60-XX30	1.18 (30)	41.7 (186)
FT80-XX06	0.23 (6)	80.7 (358)
FT80-XX12	0.47 (12)	70.2 (312)
FT80-XX30	1.18 (30)	64.7 (288)

Single (non-preloaded) nut:

$$L_{10} = (C/F)^3 S$$

$$F = [(F_1^3 s_1 + F_2^3 s_2 + F_3^3 s_3 + \ldots)/(s_1 + s_2 + s_3 + \ldots)]^{1/3}$$

Where:

L_{10} = Travel life in millions of inches (mm)
C = Dynamic load rating of roller screw, lbf (N)
F = Cubic mean load applied, lbf (N)
S = Roller screw lead, in (mm)
$F_{1,2,3...}$ = Force applied for corresponding $s_{1,2,3...}$ length of travel distance, lbf (N)
$s_{1,2,3...}$ = Length of travel distance for corresponding $F_{1,2,3...}$ applied force, in (mm)

(formulas continued next page)

Pre-Loaded (split) nut:

$$L_{10} = (L_{10(1)}^{-10/9} + L_{10(2)}^{-10/9})^{-10/9}$$

Where:

L_{10} = Travel life in millions of inches (mm)
$L_{10(1)}$ = Expected life in the extend direction, as determined by the single nut lifetime equation
$L_{10(2)}$ = Expected life in the retract direction, as determined by the single nut lifetime equation

5.2 Load, Torque, and Linear Speed Calculations

The thrust load applied by the FT actuator is dependent on the amount of torque that is applied to the roller screw shaft and the lead of the roller screw within the actuator. It is important to include any gearbox reduction and or drive train belt and pulley reduction into this equation as well. The equation that defines the amount of torque required for a corresponding required thrust force is as follows:

$$T = \frac{SF}{2\pi\eta}$$

Where:

T = Torque applied to roller screw shaft, in-lbf (N-m)
S = Roller screw lead, inches (mm)
F = Thrust force required, lbf (N)
η = Efficiency of system, 0.75 or 75% is a conservative value for all FT's (unitless)

It is also important to recognize that motor torque will be required to accelerate the inertial components of the system in addition to the thrust. Consult Exlar's sizing guideline for further details.

The linear speed that the FT actuator will produce at the end of the output rod is a function of rotational speed of the roller screw shaft and roller screw lead. It is important to include any gearbox reduction and or drive train belt and pulley reduction into this equation as well. The linear speed produced by an FT actuator is calculated by using the following equation.

$$V = nS$$

Where:

V = Linear speed, in/s (mm/s)
n = Rotational speed of roller screw shaft, rev/s
S = Roller screw Lead, in (mm)

5.3 Load and Speed Ratings

Each FT actuator model has an associated maximum force rating as seen in the table below. The maximum force rating is a value that should never be exceeded either by or applied to the actuator. Following is the peak force ratings for each FT model.

Model	Max. Force Rating, lbf (kN)
FT35	4000 (17.8)
FT60	20,000 (89.0)
FT80	40,000 (178.0)

DO NOT exceed maximum force ratings given in the table above. Doing so can and will cause damage to the actuator and put the operator at risk of injury.

The speed rating of the actuator is dependent on stroke length and diameter of the roller screw inside the actuator. The maximum rotational screw speed of the FT actuators should be maintained below the values in the table below (values in RPM):

Model	6" Stroke	12" Stroke	18" Stroke	24" Stroke	36" Stroke	48" Stroke
FT35	4500	4500	4500	4500	2700	1700
FT60	2000	2000	2000	2000	2000	2000
FT80	1750	1750	1750	1750	1750	1750

For longer strokes consult Exlar for speed considerations.

6.0 Troubleshooting

6.1 Mechanical Problems

This section will provide you with a helpful guideline to troubleshooting various problems that may occur during operation and installation of your FT actuator.

Symptom/ Problem	Possible Cause	Problem Solution
Abnormally loud whinning coming from actuator.	Misalignment or Side Load	Check alignment with application, remount actuator if necessary. Remove side load.
Abnormally loud whinning coming from actuator.	Improper servo tuning	Consult tuning guidelines for servo motor and drive.
Actuator motor rotates but output rod does not extend or retract.	Belt or inline coupling failure	Disconnect power to motor, remove belt cover and inspect belt or inline coupling. Replace if necessary.
Motor does not operate.	Motor electrical problem	Consult motor manufacturer.
Output rod has excessive rotation, or rotates but does not extend.	Anti-rotate failure	Replace anti-rotate mechanism
Case rotates along with ouput rod rotation.	Insufficient external tie rod torque.	Check assembly torque on tie rods. See section 3.6
Excessive motor current to operate actuator.	An internal mechanism binding, application binding, roller screw failure. Operation over peak load rating.	Consult Exlar

6.2 Electrical Problems

All electrical problems associated with the motor used to drive the roller screw in an FT actuator should be taken up with that motor manufacture. Exlar will assist in contacting the appropriate person.

If an externally mounted limit switch is not operating properly, check all power connections to the switch and make sure that the switch is wired properly. If the actuator has been disassembled, check to make sure that the switch groove in the case was lined up with the target magnet inside the actuator. *Refer to the diagram in section 4.4 for further details regarding correct wiring.*

6.1 Returning Product for Repair

STANDARD REPAIR LEADTIME:

- Two weeks for written evaluation from Exlar
- Two weeks from receipt of approval (by fax or email) for repair where parts are available.
- An evaluation charge per unit after evaluation applies if customer chooses not to repair; or if product is found not in need of repair.

EXPEDITED REPAIR LEADTIME:

- An expedite charge per unit can be quoted.
- This provides one week for written evaluation from Exlar
- This provides one week from receipt of approval (by fax or email) for repair where parts are available.

PROCEDURE:

- Please discuss the return with Exlar Technical Support prior to requesting an RGA number to see if it is possible to resolve the issue prior to return.
- If it is determined that an RGA number is required, please do so by contacting the Returned Goods Administrator. Phone 952-500-6200 or email returns@exlar.com.
    - International Repairs: Closely follow instructions provided by the Exlar Returned Goods Administrator. Failure to comply with issued instructions may result in delays for repair and return.
- Exlar requires a purchase order at the time of RGA; $0 on warranty returns, or for the standard evaluation charge per unit on all non-warranty units for the evaluation fee.
- Following the evaluation, you will receive a quote from Exlar on the charges that will apply. If the actuator repair is approved, the evaluation fee will be waived and we will request an amended PO for the actual repair value.